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# **5 Aggregate Specifications and Requirements**

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## **5 CHAPTER FIVE: AGGREGATES SPECIFICATIONS and REQUIREMENTS**

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Specifications are generally clear, concise, quantitative descriptions of the significant characteristics of a construction material. The specifications required by INDOT are documented in the latest edition of the Standard Specifications and the current Supplemental Specifications. The specifications for aggregates are detailed in Section **904** and other sections for the various types of construction. These specifications are to be followed when inspecting aggregates.

There are two general types of requirements for aggregate: quality and gradation.

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### **PHYSICAL QUALITY REQUIREMENTS**

Physical quality requirements are all specification provisions other than those dealing with gradation or usage requirements. These requirements can be divided into five distinct groups as follows:

- 1) Absorption;
- 2) Abrasion resistance;
- 3) Soundness;
- 4) Restrictions on deleterious constituents; and
- 5) Special requirements.

#### **Fine Aggregates**

Section **904.02** defines the acceptable limits for all uses of fine aggregates.

Fine aggregates are not divided into classes. The quality ratings assigned to fine aggregates regarding their approval for use on highway construction projects are:

A5 = approved for all uses.

B5 = approved for all uses where manufactured fine aggregate is allowed.

G5 = not approved.

The “A” rating is for all natural sands. The “B” rating is for manufactured fine aggregates.

### **Coarse Aggregates**

Section **904.03** defines the acceptable limits for all uses of coarse aggregates.

Coarse aggregates are divided into classes based on quality requirements as noted on the Classification of Aggregates table. Class AP is the highest class and is assigned to aggregates which meet the requirements for all INDOT uses. Some INDOT contracts specify type AP aggregates for use in on-grade application of portland cement concrete. Parameters concerning type AP aggregate are contained in **ITM 210**. Aggregates having restricted approval are rated Classes B, C, D, E, and F.

## **PHYSICAL QUALITY TESTS**

Approval and use of aggregates is based upon meeting physical test requirements in the following physical tests.

### **Absorption**

The absorption quality requirement applies only to coarse aggregates, but this data is necessary on fine aggregate for other purposes, such as mix design and water/cementitious ratios.

All aggregates are porous, but some are more porous than others. How porous an aggregate is determines how much liquid can be absorbed when soaked in water. The test method **AASHTO T 85** defines absorption as the increase in the weight of aggregate because of water in the pores of the material, but not including water adhering to the outside surface of the particles. Absorption is expressed as a percentage of the dry weight.

Absorption requirements are of concern only regarding aggregates used in hot mix asphalt and portland cement concrete. The intent is to avoid using highly porous, absorptive aggregates because extra water and cement or asphalt is needed to make a good mix. However, some aggregates, such as blast furnace slag, may be used despite their high absorptive capacity because of other characteristics that make them desirable, including skid resistance, economics, etc.

The maximum percentage of absorption allowed by the Standard Specifications is 5.0 percent and applies to aggregate classes AP, AS, A, B, and C only.

### **Abrasion Resistance**

**Abrasion resistance** applies only to coarse aggregates.

Aggregates vary in their resistance to fracturing under impact (toughness) and breaking down into smaller pieces from abrasive action (hardness). The acceptable limits are set by the Los Angeles Abrasion Test in the test method **AASHTO T 96**. The limits vary from 30.0 to 50.0 percent, depending on the classification of the aggregate. The percentage is a measure of the degradation or loss of material as a result of impact and abrasive actions. Section **904.03** details the requirements. Abrasion requirements do not apply to blast furnace slag.

### **Soundness**

The quality of soundness applies to both fine and coarse aggregates. The durability of aggregates or their resistance to the forces of weathering is undoubtedly one of the most important considerations in the selection of a material for highway construction. The primary exposure that INDOT is concerned with is alternate freezing and thawing.

INDOT uses three different test methods to evaluate soundness:

- 1) The water freeze and thaw test in accordance with **AASHTO T 103, Procedure A**
- 2) The sodium sulfate test in accordance with **AASHTO T 104**;
- 3) The brine freeze and thaw test in accordance with **ITM 209**.

The water freeze and thaw test requires the aggregates to be sealed and totally immersed in water and then be subjected to 50 cycles of freeze and thaw. The sodium sulfate test requires the aggregate to be immersed in a sodium sulfate solution and then be subjected to 5 cycles of alternate immersion and drying. The brine freeze/thaw requires the aggregate to be enclosed in a bag containing a 3 percent sodium chloride solution and then be subjected to 25 cycles of freeze and thaw.

The freezing and thawing in water test is the method that most accurately simulates actual field conditions, but the test requires a long period of time to conduct. The “quick” checks for soundness of the aggregate are the brine freeze/thaw and sodium sulfate test. If the aggregate fails the freeze and thaw test in water, the material is tested using either the brine freeze and thaw or sodium sulfate test. An aggregate that fails the freeze and thaw in water method but then passes the brine freeze and thaw or sodium sulfate test is an acceptable material for use on INDOT contracts.

### **Deleterious Materials**

Certain substances in aggregates are undesirable for use in portland cement concrete. Therefore, the Standard Specifications limit the amount of deleterious constituents to a level consistent with the quality sought in the final product.

Organic impurities are the only concern in fine aggregates. Section **904.02** places a restriction for fine aggregate for use in portland cement concrete and mortar. No restrictions are placed on organic impurities in fine aggregate for use in other types of construction.

The limitations on the amount of organic impurities allowed in fine aggregates are determined by the test method for organic impurities **AASHTO T 21** and the test method for Mortar Strength **AASHTO T 71**. According to the Standard Specifications, materials failing the organic impurities test are to be tested for the effect of organic impurities using the mortar strength test. The results of the test are the basis for acceptance or rejection of the fine aggregate.

Section **904.03** includes a general statement regarding deleterious substances that applies to all classes of coarse aggregates. Section **904.03** also details more specific restrictions for other harmful substances as a maximum allowable percentage of the mass of each of the deleterious materials in a total sample of aggregates being tested. Figure 4-1 illustrates the materials which are classified as deleterious and the specification limits for each.

### **Clay Lumps and Friable Particles**

Clay lumps and friable particles are materials that are easily crumbled or mashed with the fingers. Testing for these particles is performed by **AASHTO T 112**, Clay Lumps and Friable Particles in Aggregates.

### **Non-Durable Particles**

Non-durable particles are divided into two types; soft materials as determined by **ITM 206**, Scratch Hardness, and structurally weak material as determined by visual inspection.

### **Coke and Iron**

Coke and iron are of concern only with the slag materials. Coke is an ingredient in the iron making process. Slag from these furnaces normally are free of objectionable amounts of coke and iron.

### **Chert**

Chert is a rock of almost any color and is composed of glassy silicon and very fine-grained quartz. Chert breaks into rounded surfaces with sharp edges. Unweathered chert appears hard, dense and brittle with a waxy or greasy texture. Weathered chert appears chalky or earthy and porous with a dull texture. Chert is picked visually.

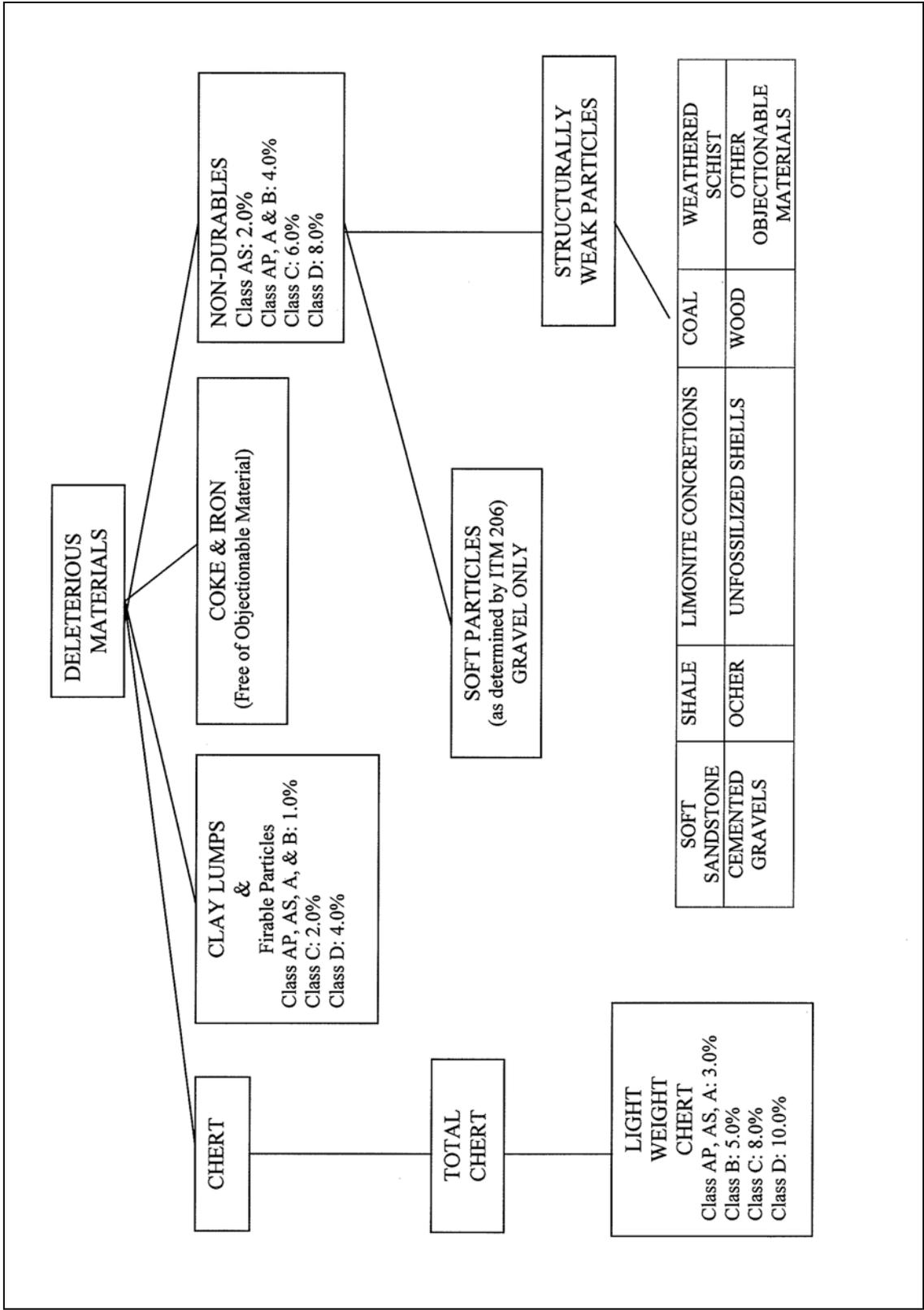


Figure 5-1. Deleterious Materials

## **SPECIAL REQUIREMENTS**

In some cases, aggregates must meet special requirements for a particular use in construction as required in various Sections of **904**. Some contracts may specify a unique gradation or aggregate. Details pertaining to this special requirement will appear in the Special Provision section of the contract proposal booklet for that contract.

### **Fine Aggregates**

All fine aggregates, except air-cooled blast furnace slag sand or granulated blast furnace slag sand, must have an acid insoluble content of not less than 40 percent. When using these slag sands, the acid insoluble content must not be less than 25 percent. The acid insoluble content is determined by **ITM 202**.

All fine aggregates used for HMA are required to be in accordance with **904.02** for soundness. If soundness testing cannot be conducted, the aggregate shall originate from a Category I source in accordance with **ITM 203**.

### **Coarse Aggregates**

#### **All Coarse Aggregates**

A special requirement placed on all coarse aggregates deals with the restriction on the number of flat and elongated pieces. Section **904.03** sets the limits for the number of flat and elongated pieces. A flat and elongated piece is defined as one having a ratio of length to thickness greater than five. The method for determining the actual percentage of flat and elongated pieces is described in test method **ASTM D 4791**.

### **Dolomitic Aggregates**

There is a special requirement to be met when dolomitic coarse aggregates are specified in HMA. These aggregates are specified for use under some conditions to obtain high-friction, skid-resistant hot mix asphalt surface courses. **ITM 205** is used to ensure that the aggregate proposed is carbonate rock containing at least 10.3 percent elemental magnesium.

### Polish Resistant Aggregates

Aggregates that meet the requirements of **ITM 214** may be used in place of dolomitic aggregates in HMA surface mixtures. The procedure for approval requires initial British Polishing testing, placement of a test section on an INDOT project, and subsequent skid testing for two years.

### Sandstone Aggregates

Coarse sandstone must meet the Class B quality requirements, and may only be used in HMA surface mixtures. The definition of sandstone is described in Section **904.02**.

### Slag Aggregates

When slag is furnished as an alternate to natural aggregate, the payment is on a weight basis, adjustments must be made to compensate for the difference in specific gravity of the slag compared to the specific gravity of the natural aggregate. For any pay item less than 500 tons on a contract, no adjustment is made. The following typical values should be used.

TYPICAL VALUES FOR SPECIFIC GRAVITY	
Natural aggregates (both fine and coarse)	2.6
Air Cooled blast furnace slag coarse aggregate	2.3
Air cooled blast furnace slag fine aggregate	2.6
Granulated blast furnace slag fine aggregate	2.1
Steel furnace slag, both fine and coarse	3.2

### Gravel Coarse Aggregates

There is a specific requirement for gravel coarse aggregates regarding crushed particles. This requirement applies, however, only when gravel coarse aggregates are used in HMA, compacted aggregates, and asphalt seal coats except asphalt seal coats used on shoulders. Crushed particles are defined as those particles having one or more sharp, angular, fractured faces. Fractured faces that have an area less than 25 percent of the maximum cross sectional area of the particle are not considered crushed. **ASTM D 5821** is used to determine the crushed particle content. Crushed gravel must comply with the requirements in Section **904.03**.

### **Type AS Aggregates**

Aggregates used for stone matrix asphalt mixtures are required to meet the requirements of AS aggregates in accordance with Section **904.03 (a)**. These requirements include testing with the Micro-Deval abrasion apparatus (**AASHTO T 327**) and determination of the aggregate degradation in accordance with **ITM 220**. Additional requirements for control of the specific gravity of the steel furnace slag are included in Section **904.01**.

### **Type AP Aggregate**

INDOT requires that contracts with on-grade portland cement concrete be constructed with AP aggregate. Details and parameters concerning AP aggregate are described in **ITM 210**.

### **Blended Aggregates**

The total blended aggregate from the fine and coarse aggregates, and recycled materials used in HMA shall meet the fine aggregate angularity (FAA) requirements of Section **904.02(b)**. The procedure for determining the FAA value is described in **AASHTO T 304**.

The clay content of the blended aggregate shall meet the requirements of Section **904.02(b)**. The procedure for determining this value is described in **AASHTO T 176**.

## **GENERAL USAGE REQUIREMENTS**

The general usage requirements first describes the type of material which is considered acceptable for the type of construction, and, second, describes the requirements which influence the acceptability of the material.

### **Fine Aggregates**

Section **904.02** states that fine aggregate shall consist of natural sand or manufactured sand produced by crushing limestone, dolomite, steel furnace slag, air cooled blast furnace slag, or wet bottom boiler slag. At the time of use these materials shall be free from lumps or crusts of hardened or frozen materials. The detection of lumps or crusts of hardened or frozen materials is possible only through visual inspection.

THE SPECIFIC REQUIREMENTS OF FINE AGGREGATES  
IN ACCORDANCE WITH SECTION 904.02:

<i>TYPE OF CONSTRUCTION</i>	<i>ACCEPTABLE FINE AGGREGATE</i>
Portland cement concrete for pavement or bridge decks	Natural sand
Portland cement concrete for other construction	Natural sand or crushed limestone, dolomite, or air-cooled blast furnace slag.
Hot mix asphalt	<p>Natural sand or manufactured sand.</p> <p>Steel furnace slag sand is permitted only with Steel furnace slag coarse aggregate.</p> <p>Combination of natural sand and manufactured sand is permitted. However, not more than 20 percent of the total aggregate used in HMA surface mixtures with ESAL equal to or greater than 3,000,000 may be crushed limestone sand if the limestone sand is from a source not on the Approved Polish Resistant Aggregate List.</p>
Pneumatic placement	Natural sand suitable for use with a pneumatic sand cement gun.
Mortar	Natural sand
Mineral Filler	Dust produced by crushing stone, portland cement, or other inert mineral matter.
Snow and ice abrasives	Steel furnace slag, air-cooled blast furnace slag, granulated blast furnace slag, natural sand, crushed stone sand, or cinders.

## Quality Ratings

The minimum quality rating for a specified use of fine aggregate is as follows:

Portland Cement Concrete for Pavement or Bridge Decks	A5
All Portland Cement Concrete except pavement or Bridge Decks	A5 or B5
All HMA/CMA Mixtures	A5 or B5
Pneumatic Placement	A5
Mortar	A5
Mineral filler	(None Specified)

### Description for quality ratings for fine aggregate

- A5 Material meets quality requirements for all uses of Fine Aggregate
- B5 Material meets quality requirements for all uses of Fine Aggregate permitting manufactured Fine Aggregate.
- G5 Material does not meet Fine Aggregate quality requirements for any INDOT use.

## Coarse Aggregates

Section **904.03** includes the general requirements for coarse aggregate. This section lists several of the types of materials that can be used as coarse aggregate, and their applications and limitations.

CLASS OF COARSE AGGREGATES REQUIRED FOR VARIOUS TYPES OF CONSTRUCTION	
<i>TYPE OF CONSTRUCTION</i>	<i>REQUIRED QUALITY CLASSIFICATION</i>
Aggregate Base	Class A, B, C, or D
Subbase	Class A or B (No. 8.) Class A, B, C, or D (No. 53)
Aggregate Pavements or Shoulders	Class A, B, C, or D
HMA base course	Class A, B, C, or D
HMA intermediate course	Class A, B, or C
HMA surface course	Class A or B
SMA surface course	Class AS
Asphalt seal coat	Class A or B
Portland cement concrete pavement	Class AP
Portland cement concrete structural-- exposed	Class A or AP
Portland cement concrete structural-- non-exposed	Class A or B
Cover (choke) aggregates coarse aggregate	Class A or B

When more than one aggregate classification is allowed, the contractor or producer has a choice, unless specified by provisions within a given contract. The class of aggregate can never be less than the lowest class for the designated use. For example, the highest class of aggregate for HMA surface course, Class A, may be used (with no additional payment to the contractor or producer). Class B aggregate may be used as the minimum requirement. For portland cement concrete pavement, the aggregate is required to be Class AP.

## Quality Ratings

The minimum quality rating for a specified use of coarse aggregate is as follows:

No. 8 Exposed Concrete	A1
No. 11 Exposed Concrete	A3
No. 8 Non-Exposed Concrete	B1
HMA/CMA Surface	B1, B2, or B3
No. 8 Seal Coats	B1
No. 9 Seal Coats	B2
No. 11 Seal Coats	B3
No. 12 Seal Coats	B3
HMA/CMA Intermediate	C1, C2, or C3
HMA/CMA Base	D1
No. 43 Compacted Aggregate Base	B1
No. 53 Compacted Aggregate Base	D1
No. 73 Compacted Aggregate Base	D1
No. 8 Aggregate for Shoulder Drains	E1
No. 11 Aggregate for Shoulder Drains	E3
No. 12 Aggregate for Shoulder Drains	E3
Rip Rap	F1

Description of quality ratings for coarse aggregate

- A0 Material meets requirements for all uses requiring AP Coarse Aggregates.
- A1 Material meets quality requirements for all uses of Coarse Aggregate.
- A2 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 3/4 in.
- A3 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 1/2 in.
- A4 Material meets quality requirements for Class A Coarse Aggregate, but is only approved for the special gradation submitted.
- B1 Material meets quality requirements for all uses of Coarse Aggregate except for use in exposed Portland Cement Concrete.
- B2 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 3/4 in. except it is not approved for use in exposed Portland Cement Concrete.
- B3 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 1/2 in. except it is not approved for use in exposed Portland Cement Concrete.
- B4 Material meets quality requirements for Class B Coarse Aggregate, but is only approved for the special gradation submitted.
- C1 Material meets quality requirements for all uses of Coarse Aggregate except for use in Portland Cement Concrete or in HMA/CMA Surface Mixtures.
- C2 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 3/4 in. except it is not approved for use in Portland Cement Concrete or in HMA/CMA Surface Mixtures.
- C3 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 1/2 in. except it is not approved for use in Portland Cement Concrete or in HMA/CMA Surface Mixtures.

- C4 Material meets quality requirements for Class C Coarse Aggregate, but is only approved for the special gradation submitted.
- D1 Material meets quality requirements for all uses of Coarse Aggregate except for use in Portland Cement Concrete or in HMA/CMA Mixtures.
- D2 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 3/4 in. except it is not approved for use in Portland Cement Concrete or in HMA/CMA Mixtures.
- D3 Material meets quality requirements for all uses of Coarse Aggregate with a top size not exceeding 1/2 in. except it is not approved for use in Portland Cement Concrete or in HMA/CMA Mixtures.
- E1 Material meets quality requirements for Coarse Aggregate for use in granular subbase, subsurface drains, or rip rap.
- E2 Material meets quality requirements for Coarse Aggregate for use in granular subbase, or subsurface drains with a top size not exceeding 3/4 in.
- E3 Material meets quality requirements for Coarse Aggregate for use in granular subbase, or subsurface drains with a top size not exceeding 1/2 in.
- E4 Material meets quality requirements for Class E Coarse Aggregate, but is only approved for the special gradation submitted.
- F1 Material meets quality requirements for Rip Rap Aggregate.
- F4 Material meets quality requirements for Class F Coarse Aggregate, but is only approved for the special gradation submitted.
- G1 Material does not meet Coarse Aggregate quality requirements for any INDOT use.

## GRADATION REQUIREMENTS

The gradation or particle-size distribution of an aggregate is usually specified to be within certain limits for various types of construction. There is a great difference between what is considered an acceptable grading for aggregates for HMA, for portland cement concrete, or for base layers. The gradation that aggregates are required to meet for specific types of construction is contained in the contract plans, special provisions, or standard specifications and is usually designated by the aggregate size.

Sections **904.02** and **904.03** contain tables describing the acceptable particle-size distribution for various sizes of both fine and coarse aggregates. Section **904.04** outlines the acceptable gradations for riprap and Section **904.05** specifies the sizes for structure backfill.

### Fine Aggregates

The table found in Section **904.02** is used to accept six aggregates used for HMA, portland cement concrete, pneumatic placement mortar, mortar sand, mineral filler, and snow and ice abrasives. The table lists the six sizes of fine aggregates--number 23, 24, 15, 16, PP, and S & I. Number 16 is the finest aggregate, because 100 percent of the fine aggregate must pass the No. 30 sieve. Number 23 is the coarsest of the six sizes. Note that all fine aggregate particles are generally expected to pass the No. 4 sieve.

The aggregates for mortar sand must meet the gradation for size number 15 or an approved gradation from a CAPP source. The fine aggregates for pneumatic placement may meet size number 15, PP, or an approved gradation from a CAPP source. Mineral filler for SMA is required to meet size number 16.

Snow and ice abrasives must meet the gradation requirement of Section **904.02(f)**.

### Coarse Aggregates

The table found in Section **904.03** applies to coarse aggregates. The table shows ten sizes of coarse aggregates--numbers 2, 5, 8, 9, 11, 12, 43, 53, 73, and 91. Number 2 is the coarsest size and number 12 is the finest. Numbers 53 and 73 are dense graded aggregates and number 91 is used for aggregates in pre-cast concrete. Note that the majority of the aggregate is retained on the No. 4 sieve and larger.

## **B Borrow and Structure Backfill**

B Borrow and structure backfill requirements are listed in Section **211**.

Materials for B borrow are required to contain no more than 10 percent passing the No. 200 sieve and shall be otherwise suitably graded as noted in Section **211.02**. The use of an essentially one-size material will not be permitted unless approved.

Structural backfill gradations are listed in Section **904.05**. The percent of material required to pass varies by aggregate size. For example, for the 2 in. aggregate, at least 90 percent should pass the 2 in. sieve. For the 1 in. aggregate, at least 85 percent should pass the 1 in. sieve and for the No. 30 aggregate, at least 70 percent should pass the No. 30 sieve.

## **Riprap**

Aggregate used for this purpose is found in Section **904.04**. These materials are typically large and are used as a protective coating as specified. Revetment, Class 1, Class 2, and Uniform Riprap shall meet the requirements of Section **904.04(f)**. The other r ripraps listed have general size limitations.

## **Aggregate Base**

Section **301** includes the requirements for dense graded compacted aggregate material. No. 53 aggregate is used for this purpose.

## **Subbase**

Section **302** includes the requirements for subbase placed on a prepared subgrade for PCCP. Subbase consists of a No. 8 or aggregate as the drainage layer over a No. 53 aggregate as the separation layer. Where a dense graded subbase is required, only No. 53 aggregate is used.

## **Aggregate Pavements or Shoulders**

Section **303** includes the requirements for pavements or shoulders. No. 53 and No. 73 aggregate is used for this purpose except that No. 73 aggregate is only used for surface courses.

## Summary of Gradation Requirements

The gradation requirements for fine and coarse aggregates as specified in various sections of the Standard Specifications for significantly different types of construction are summarized below. This listing is not all-inclusive, but covers the major uses of aggregates. A review of the Standard Specifications shall always be necessary.

TYPE OF CONSTRUCTION REQUIREMENTS	GRADATION
Aggregate Base * Coarse aggregate	No. 53
Subbase * Coarse aggregate	Nos. 8, 53
Aggregate Pavements or Shoulders * Coarse aggregate	Nos. 53, 73
Asphalt Seal Coat * Fine aggregate * Coarse aggregate	Nos. 23 or 24 Nos. 8, 9, 11, 12
Portland cement concrete pavement/structural * Fine aggregate * Coarse aggregate	No. 23 No. 8